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Environmental Effects of Dredging
Technical Notes

GUIDE TO SELECTING A DREDGE FOR MINIMIZING RESUSPENSION OF SEDIMENT

PURPOSE: This technical note contains assessments of conventional and special-purpose dredges in removing sediment with minimal sediment resuspension. If sediment resuspension is a critical factor in dredging areas of contaminated material, the following guidance will aid in specifying the dredge and operating conditions.

BACKGROUND: Investigations were conducted as part of the Corps of Engineers' Improvement of Operations and Maintenance Techniques (IOMT) Research Program to evaluate the resuspension of sediment into the water column due to dredging operations. Laboratory, field, and literature studies have been used to define the sediment resuspension characteristics of most conventional and several special-purpose dredges. The natural hydrophobic tendency of most organic contaminants and the high sediment-sorptive capacity for inorganic contaminants limits release to the soluble forms and makes the simple measure of sediment resuspension during dredging a relative measure of the potential for contaminant release.

DEFINITION OF SEDIMENT RESUSPENSION: For the purpose of this technical note, the sediment resuspension caused by a dredging operation is defined as those sediment particles resuspended into the water column during the dredging operation that do not rapidly settle out of the water column following resuspension. This includes any resuspension by barge or hopper overflow, spillage, leakage, spud movement, or other contributors directly related to the dredging operation. Contributions of sediment from the prop wash by tenders, barge movement, or other operations not directly involved in the dredging operation are not considered in this definition. The method of disposal was not considered in evaluating the sediment resuspension or in the rating of various dredge types.

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Approach

The results were derived from suspended solids measurements from discrete water samples taken at various depths in the water column at field study sites. The trends observed at the field sites are shown as suspended solids concentrations (adjusted for background conditions) for three sections of the water column: upper, middle, and lower, each being one-third of the total depth.

Assessment of Resuspension Potential

Conventional dredges

Conventional dredges include unmodified types commonly used in the United States such as hydraulic dredges (e.g., cutterhead, dustpan, and hopper dredges) and mechanical dredges (e.g., the bucket or clamshell dredge). Operational parameters that affect sediment resuspension are discussed, and control measures that may reduce resuspension are presented.

Cutterhead dredges. The popular high-production cutterhead dredge may not seem a very likely candidate for efficient removal of contaminated sediment because of the high-energy cutting and sweeping actions associated with its operation. However, field studies conducted in the James River near Norfolk, Va. (Raymond 1984) and in the Savannah River near Savannah, Ga. (Hayes et al. 1984) indicated that the cutterhead dredge is capable of removing sediment with relatively small amounts of resuspension extending beyond the immediate vicinity of the dredge as compared to other conventional dredge types. Figure 1 gives an indication of typical suspended solids concentrations in a turbidity plume generated by a cutterhead dredging operation.

Research under the IOMT Program has shown that sediment resuspension by a cutterhead dredge can be reduced by proper selection of the cutter rotation speed, ladder swing speeds, and depth of cut. This does not suggest that restrictions should be placed on these parameters to minimize resuspension. In fact, data presented by Hayes et al. (1984) suggest that the optimum selection of these parameters for minimum resuspension generally corresponds to the selection for achieving highest production. So by properly optimizing production, as every dredge operator attempts to do, minimum resuspension will usually occur. The primary exception to this is the practice of undercutting

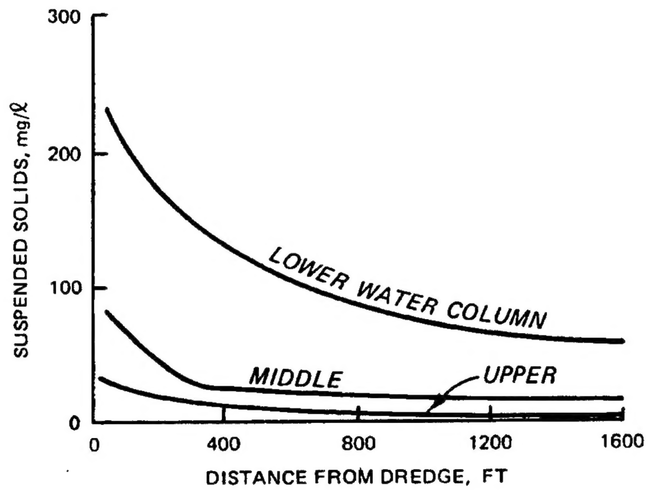

Figure 1. Resuspended sediment levels from cutterhead dredge operations in the Savannah River

to remove large banks of material (i.e., material thickness of 10 ft or greater). This technique involves cutting the bank at near the project depth and allowing the large volume of overlying bank material to collapse into the cutterhead. Overload of suction capacity of the inlet pipe may occur, causing excess sediment particles to be resuspended rather than carried through the pipe. For this reason, excessive submergence of the cutterhead below the sediment line should be avoided.

Dustpan dredges. The dustpan dredge is a hydraulic suction dredge that uses a widely flared dredgehead along which water jets are mounted. The jets loosen and agitate sediment particles, which are then captured in the dustpan dredgehead as the dredge moves forward. This type of dredge works best in free-flowing granular material and is not generally used to dredge fine-grained (clay) sediment. However, in 1982, an experiment was conducted using a modified dustpan head (without water jets) to dredge fine-grained sediment in the James River. A modified dustpan head and a conventional cutterhead were operated in the same reach of the river for comparison. It was hoped that the modified dustpan head using suction only could excavate thin layers of contaminated clay sediment with less resuspension than a cutterhead. Unfortunately, the dustpan head experienced repeated clogging and produced at least as much resuspension as the cutterhead operating in the same material (Raymond 1984).

Hopper dredges. Hopper dredges typically remove sediment by dragging a large flat draghead and using hydraulic suction to remove the disturbed material. Because of the location of the drag arm beneath the dredge, it is difficult to measure the resuspension near the draghead; however, data presented by Hayes et al. (1984) indicated that the resuspension without overflow may actually be less than for a cutterhead dredge.

A hopper dredge can continue to operate beyond the initial filling of the hoppers and discharge overflow from the hoppers into surrounding waters, resulting in a large increase in the turbidity plume. The differences between the turbidity plume generated by overflow and nonoverflow operations are shown in Figure 2. This suggests that some restrictions on overflow may be necessary if a hopper dredge is used for removing contaminated sediment.

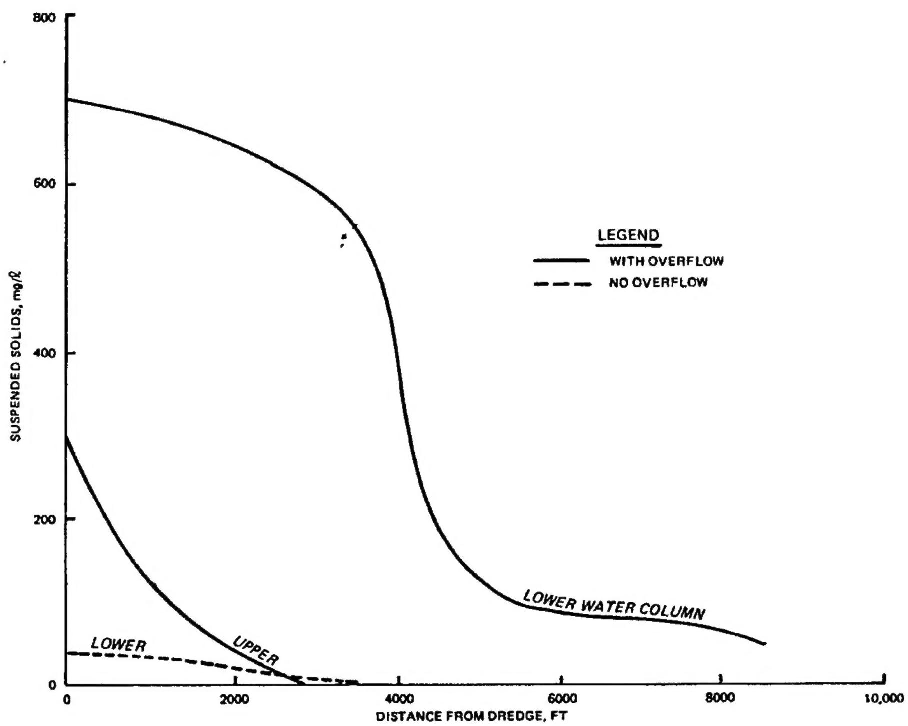

Figure 2. Resuspended sediment levels measured behind the dredge during hopper dredge operations in Grays Harbor with and without overflow

Bucket dredges. Clamshell dredges, the most common type of bucket dredge, are typically used in areas where hydraulic dredges cannot work because of the proximity of piers, docks, etc., or where the disposal area is too far from the dredge site for it to be feasible for a cutterhead dredge to

pump the dredged material. Resuspension from operation of open-bucket clamshell dredges is typically higher than that from most cutterhead dredges. This resuspension is generally due to the dynamic impact of the bucket on the channel bottom, the spillage and leakage from the filled bucket, and the washing action of the empty bucket falling through the water column. Resuspension levels of the dredging operation are even higher when the scow is allowed to overflow.

Sediment resuspension from clamshell dredges can be reduced by the use of an enclosed clamshell bucket. This bucket significantly reduces spillage and leakage, which are major contributors to the turbidity plume. Figure 3 shows the benefit of using an enclosed bucket. The operation of the dredge can be modified slightly to reduce sediment resuspension by slowing the raising and lowering of the bucket through the water column. It must be noted that this operational modification reduces the production rate of the dredge.

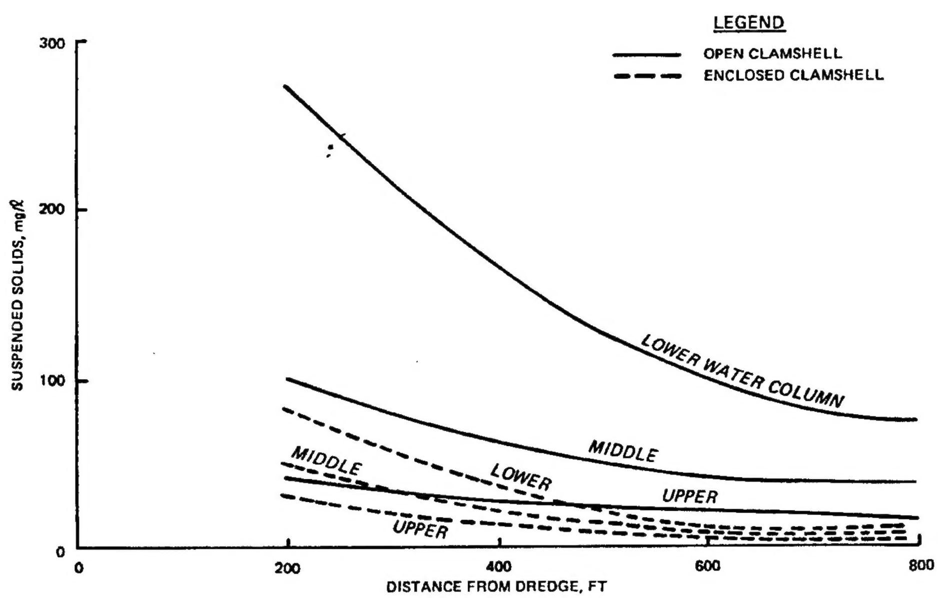

Figure 3. Resuspended sediment levels from open and enclosed clamshell dredge operations in the St. Johns River

<u>Special-purpose dredges</u>

Special-purpose dredging systems have been developed during the last few years in the United States and overseas to pump dredged material slurry with a high solids content and/or to minimize the resuspension of sediment. Most of these systems are not intended for use on typical maintenance dredging

Pneuma pump	48 mg/ℓ 3 ft above bottom 4 mg/ℓ 23 ft above bottom (16 ft in front of pump)
Clean-Up System	1.1 to 7.0 mg/ℓ above suction 1.7 to 3.5 mg/ℓ at surface
Oozer pump	Background level (6 mg/ℓ) 10 ft from head
Refresher System	4 to 23 mg/ℓ 10 ft from head

* Suspended solids concentrations were adjusted for background concentrations.

Summary

The IOMT research has shown that most conventional dredges can be used to remove sediment with a limited amount of sediment resuspension if they are properly operated and a few precautions are taken or plant modifications are made. This can be accomplished with only a small increase in cost over a normal dredging operation, and typically conventional dredging equipment is readily available. The data show that cutterhead dredges and hopper dredges with no overflow generate less resuspended sediment than mechanical dredges. The following tabulation gives a summary of suspended sediment levels observed during IOMT field studies. However, in many cases, maneuverability requirements, hydrodynamic conditions, location of the disposal site, and other factors may dictate the type of dredge that must be used; the strategy then must be to minimize the resuspension levels generated by that dredge.

If no conventional dredge is acceptable, a special-purpose dredge may have to be selected. These dredges generally resuspend less material than conventional dredges, but associated costs may be much greater. As in the case of conventional dredges, the selection of a special-purpose dredge will likely be dictated by logistics, economics, and availability.

Dredge Type	Downcurrent Distance-Suspended Solids Concentration, mg/ℓ* Within 100 ft	Within 200 ft	Within 400 ft
Cutterhead	25 - 250	20 - 200	10 - 150
Hopper			
With overflow	250 - 700	250 - 700	250 - 700
Without overflow	25 - 200	25 - 200	25 - 200
Clamshell			
Open bucket	150 - 900	100 - 600	75 - 350
Enclosed bucket	50 - 300	40 - 210	25 - 100

* Suspended solids concentrations were adjusted for background concentrations.

Future Developments

Research is being conducted to identify modifications to conventional dredges that may decrease the sediment resuspension to levels nearer those of special-purpose dredges. An example is the matchbox suctionhead tested by the US Army Engineer District, Chicago. The Dutch-developed matchbox suctionhead entrains sediment into the suction pipe of a hydraulic dredge by using the swinging action to force material into a large funnel-shaped opening on one side of the suctionhead and adding water through the other side. Since the suctionhead is symmetrically designed, it will operate during swings in both directions.

References

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